REGENERATION OF *ACACIA MELVILLEI* IN PART OF SEMI-ARID SOUTH-EASTERN AUSTRALIA

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The regeneration of the tree *Acacia melvillei* (yarran) was studied in a semi-arid area within 100 km of Balranald, south-west New South Wales using size-class analysis and seedling transplants into a remnant stand. Almost total regeneration failure was found in all pastoral areas except for a few sites known or presumed to have experienced intermittently low browsing pressure. At these sites, two recruitment episodes are tentatively assigned to the 1950s and to 1973–1975. In dryland cropping areas, root damage by cultivation can produce profuse regeneration by root suckering. This is seen as an artefact of European land use practices. The transplants showed that seedling establishment can be strongly limited by low soil moisture in spring and summer and by rabbit browsing. Retaining *A. melvillei* in biological reserves will require strict rabbit control. In addition, pastoral areas will require stock removal during and after the wet years needed for regeneration.

IN SEMI-ARID and arid Australia, research is producing a growing list of tree species whose regeneration is strongly inhibited or prevented by browsing of seedlings and suckers by introduced mammals (Chesterfield & Parsons 1985, Auld 1990, Parsons 1990). While the list includes a number of *Acacia* species (Auld 1990), many *Acacia* spp. have yet to be studied. Ability to sucker is not well documented and the relative importance of seedlings and suckers in the perpetuation of stands is often not understood. Here we investigate regeneration from seedlings and suckers under a variety of browsing and clearing regimes in *Acacia melvillei* Pedley (yarran), a community dominant in parts of inland Queensland, New South Wales and Victoria.

THE SPECIES

Acacia melvillei has only recently been distinguished from *A. homalophylla* Cunn. ex Benth. Both species are widespread throughout the southern part of inland Queensland and inland New South Wales, with more limited occurrences in northern Victoria (Pedley 1978).

Mature pods are needed to distinguish the two species reliably. While these were not available during the present study, all reliably named herbarium specimens seen from our study area at MEL and NSW were labelled *A. melvillei* (M. Fox personal communication; our own data). This, and the number of flowers per head on our plants, strongly suggest that all the yarran plants we saw were *A. melvillei*.

In our study area, *A. melvillei* occurs as the sole dominant of a woodland community on reddish loam flats.

THE STUDY AREA

All sites were within 100 km of Balranald (Fig. 1), where the climate is the cool, semi-arid BSk type (Dick 1975) and mean annual rainfall ranges from about 280 mm to 330 mm. Grazing by stock (mainly sheep) and by rabbits has been widespread since the 1870s (Condon 1983, New South Wales Soil Conservation Service 1990). Sites were chosen to encompass the drier, pastoral areas in the north and the wetter, dryland cropping areas in the south (Fig. 1, Table 1). Few sites could be found with a history of low grazing pressure (known for site 4; inferred for site 6, see Table 1). Sampling was concentrated in those few areas where some regeneration had occurred in the last 40 years or so (sites 4 to 10, Table 1). Many stands lacking regeneration were present in the area; only three of these were sampled (sites 1 to 3, Table 1). It proved very difficult to obtain records of grazing history because the leases for many pastoral areas have changed hands in the last ten years or so.

METHODS

Size class analysis

To provide regeneration data rapidly over a wide area, *Acacia melvillei* stem girths were measured in single, large, unreplicated, subjec-

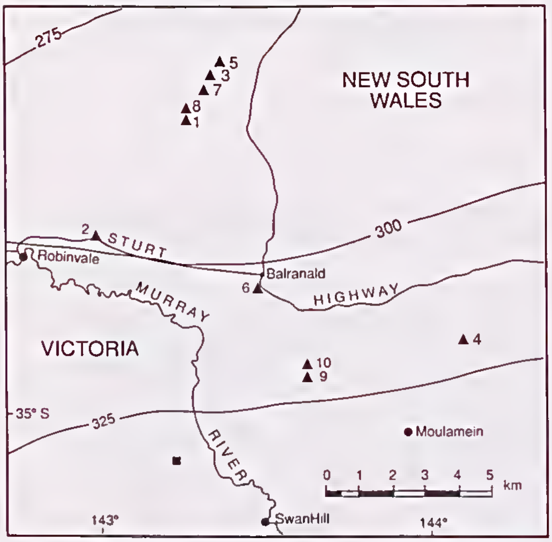

Fig. 1. Location of the study sites and mean annual isohyets (mm) in south-west New South Wales and north-west Victoria. Triangles = size class analysis sites; square = seedling survival site.

tively chosen plots, following previous work (Crisp & Lange 1976, Chesterfield & Parsons 1985). Stems were measured 15 cm above ground to avoid buttressing. In multistemmed plants, stems less than 5 cm in girth were ignored; for those greater than 5 cm girth, the girths were converted to cross-sectional areas and these added to obtain total girth (Fritts 1969). This seemed the best approach given that, in some of the oldest stands, up to half the trees were multistemmed, not single-stemmed. Plot size was varied (Table 1) so that about 75 trees were sampled in each (including dead ones). If fewer than 75 were present, whole populations were sampled.

Seedling survival

Effects of climate and rabbit grazing on seedling establishment were examined in Flora Reserve G67, a 23 ha stock-free area (Victoria: Land Conservation Council 1989) carrying some *Acacia melvillei* trees at Yarraby north-west of Swan Hill (Fig. 1).

Rabbit-proof cages were made and a field trial set up as 3 planting dates × 2 treatments (caged and uncaged) × 4 replicates. All plots were at least 12 m from the nearest tree. Seedlings were raised in a glasshouse using *Acacia melvillei* seed collected on 15 January 1990 from between Goschen and Ultima (map reference Nyah 7527, 714 228). On each date (6 weeks apart), plots were planted with four-week-old seedlings with cotyledons and one to two fully expanded leaves. They were planted open-rooted in four rows of three at 10 cm spacing, into plots from which all plants (mainly exotic annual grasses) had been removed. On planting day, each plot received 10 L of water, 6 L before planting and 4 L after. No further water was applied. The site was a reddish loam flat.

On later visits, seedlings were recorded as being: (a) live; (b) dead-browsed—these had the shoots bitten off, generally below the cotyledons, and none resprouted; or (c) dead-unbrowsed—whole shoot still present. A minority (1%) had disappeared completely for reasons unknown. The trial was terminated on 9 September 1991, 5 weeks after the final planting. The data were analyzed by chi-squared tests.

The field work was carried out between February and September 1991 except for brief checks on seedling survival on 30 November 1991 and 25 March 1992; voucher specimens have been lodged at La Trobe University Botany Department Herbarium (LTB).

RESULTS

Size class analysis

The girth histograms can be readily divided into four groups based on the varying sizes of dead and alive trees (Fig. 2). Populations in group one showed abundant evidence of sheep and rabbit grazing and a general absence of regeneration. Most *Acacia melvillei* individuals were dead (Figs 2, 3A) and there was an absence of individuals in size classes smaller than 80–100 cm except for two plants in the 10–20 cm size class at site 1. These had grown up through the dense canopies of chenopod shrubs which had presumably acted as nurse plants. Excavation showed both to be seedlings, not suckers.

Group one contains an average of 8% live plants; these are old, with decumbent, collapsing stems and usually less than half their branches left alive. In the pastoral parts of the study area, these degenerating stands mostly devoid of regeneration are by far the most common type seen; e.g. various areas around sites 1, 2, 3, 4 and 7. In a number of cases, all that remains of *Acacia melvillei* stands are a few dead and fallen trunks, lying on virtually bare loamy flats surrounded by healthy mallee vegetation on higher ground.

Group	Site	Location	Grid reference	No. of plants measured	Area sampled (ha)	Grazing/clearing	Records of regeneration	Presence of regeneration
1	1	Bidura Station	YH016015	59	1.5	Sheep, rabbits	None	No
	2	Topra Plains Station	YG833759	63	1.3	Sheep (hcavy), rabbits	None	No
	3	Hillview Station	YH026026	79	0.9	Sheep, rabbits (heavy)	None	No
2	4	Tchelery Soil Conservation Service Experimental Area (71 ha)	BB479418	77	0.6	Rabbits (periodic), no sheep since 1952	1952–1953	Yes
	5	Hillview Station home paddock	YH026029	80	0.3	Sheep, rabbits	Early 1950s	Yes
	6	Public stock reserve S of Balranald	YG345613	80	0.2	Sheep (periodic), rabbits	None	Yes
3	7	Wintong Station	YH024023	55	1.0	None available	None	Yes
	8	Bidura Station	YH017016	83	0.5	Sheep, rabbits	1 m high in 1978	Yes
4	9	Moolpa Station	YG478325	41	0.06	Cleared 1972, last cropped 1976, very light stock grazing since	1977	Yes
	10	Moolpa Station	YG482332	58	0.05	Cleared 1977, last cropped 1980, very light sheep grazing sincc	1981	Yes

Table 1. General characteristics of the study sites including details of *Acacia melvillei* regeneration. Grid references are from 1:100,000 topographic maps or orthophotomaps.

Weeks since planting	Observation date (1991)	Caged				Uncaged			
		Live	Dead-browsed	Dead-unbrowsed	Disappcared	Live	Dead-browsed	Dead-unbrowsed	Disappeared
(a) First planting									
6	25 June	69	0	31	0	31	29	40	0
12	7 Aug	69	0	31	0	23	37	40	0
18	11 Sept	52	0	46	2	8	44	46	2
(b) Second planting									
6	7 Aug	100	0	0	0	94	4	2	0
12	11 Sept	83	0	15	2	59	27	12	2
(c) Third planting									
6	11 Sept	75	0	25	0	38	33	29	0
Percentage over all plantings on 11 Sep		70	0	29	1	35	35	29	1

Table 2. Survival and causes of dcath (as pcrcentages) for seedlings of *Acacia melvillei* planted on three dates inside and outside cages. Percentagcs are based on n = 48.

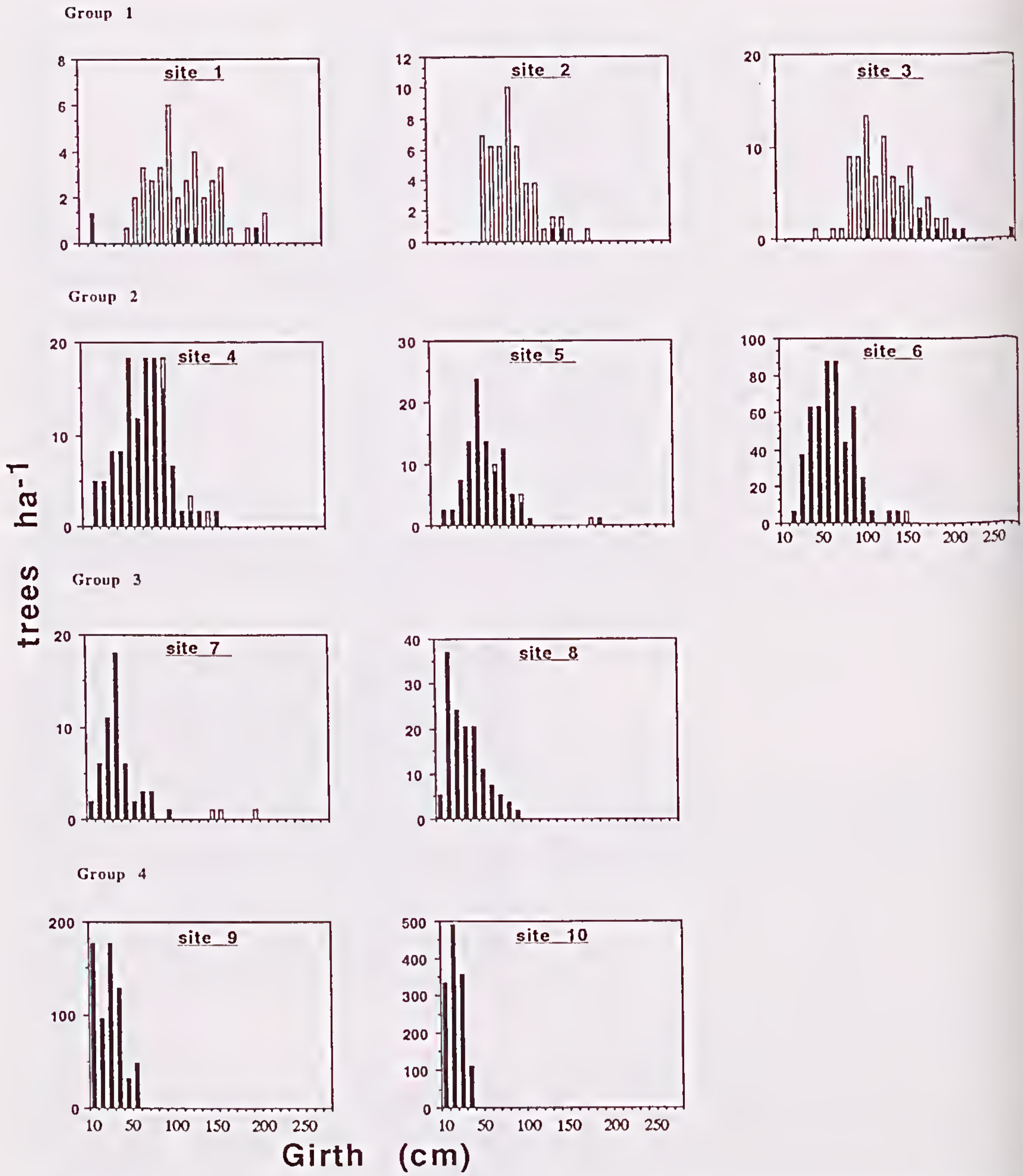

Fig. 2. Girth histograms for stands of *Acacia melvillei* divided into groups of similar size structure. Shading shows live plants, no shading shows dead ones. Vertical scale varies.

Although some of the few live plants in group one have similar girths to plants in group two, their dead branches and sparse canopy make them readily distinguishable from group two plants with their dense canopies and strongly suggest that they are from an earlier episode of regeneration.

Stands in groups two and three are mostly of living plants (Fig. 3B, C). While group three has a few plants in the smallest size class, the few that are less than 1 m high have been suppressed by browsing. In both groups there is a lack of recent recruitment (Fig. 2). In any given stand, most plants appear to be of similar age and possibly from a single recruitment event, with the group two stands being older than those of group three. Group two plants typically have canopies wider in relation to their height than group one plants (Fig. 3B,C). There were a few dead or degenerating trees at each site, including site 8 where, however, they were absent from the quadrat. Excavation of small plants at each site showed they were of seedling origin in every case.

Taken together the group two data (Fig. 2, Table 1) suggest that group two sites carry substantial regeneration from the early 1950s. Site four was exclosed from stock in 1952 but rabbits periodically infest the area between control measures such as ripping (R. Scriven personal communication), and there have been episodes of stock entry (Semple 1986). Regeneration commenced in 1952–1953 soon after exclosure (Soil Conservation Service, Hay, unpublished records). Of groups two, three and four, this site shows the greatest range in sizes of *A. melvillei*, from plants 1 m tall to large, degenerating trees. It may well be an exception to a possible general trend to even-aged stands in these three groups. On the same soil type outside the exclosure, *Acacia melvillei* regeneration was absent; only dead (the great majority) or very degenerate plants occurred (see also Semple 1987).

Further evidence linking group two to the 1950s is an eyewitness report that the present live plants at site 5 first appeared in the early 1950s (Gordon Neil personal communication). This would accord with regeneration episodes of other species in the 1950s during above-average rainfall years and myxomatosis-induced reduction in rabbit numbers at that time (Hall et al. 1964, Chesterfield & Parsons 1985). At Balranald, 1952, 1954, 1955, 1956 and 1958 had above-average rainfall. For group three the only dating we have is that the live plants at site 8 were about 1 m high when seen in 1978 (Greg Ayson personal communication). The live plants at sites 7 and 8 could well relate to exceptionally wet years in 1973–1975, as do similar episodes in nearby areas (Chesterfield & Parsons 1985).

The group 4 sites are on areas that had been cultivated and used for cereal crops in the 1970s. When cropping stopped, profuse regeneration became obvious (Fig. 3D), mainly from root suckering but occasionally from seed (Fig. 4). The size class difference between sites 9 and 10 (Fig. 2) accords well with their known history (Table 1). The site 9 histogram is bimodal (Fig. 2), with the 0–10 cm peak indicating a younger generation of root suckers, possibly a response to root damage around the base of the trees caused by cattle hooves. Microscopic examination of transverse sections confirmed that the suckers at sites 9 and 10 originated from roots, not rhizomes.

Seedling survival

Of untreated seeds set out to germinate at 25°C, only 10% germinated; the proportion was increased to 95% by placing seeds in boiling water or by nicking the seed coat. As expected, rainfall was lowest and temperatures highest for the first and last six weeks of the trial (Fig. 5). The first planting in mid-May was made in dry conditions after below-average autumn rainfall. Winter rainfall was slightly above average.

On all three observation dates after the first planting, overall seedling mortality was higher in uncaged plots than in caged ones (Table 2). No dead-browsed seedlings were found in cages so invertebrate effects were not detected. The only signs of vertebrates were rabbit scats and rabbits which are assumed responsible for all browsing deaths. After six weeks in uncaged plots, browsing mortality varied significantly ($P < 0.001$) between planting dates, with smaller losses in the moist, cool winter period when fresh, green herbs were abundant as an alternative food source.

The deaths of unbrowsed seedlings were not related to transplanting damage. Mortality was greatest during the dry periods of May–June and August–September and was very low in the moist second six weeks of the trial when it was much less than browsing losses (Table 2). The data strongly suggest that the deaths of unbrowsed seedlings were due almost entirely to drought and that frost was unimportant. In 1991, only 12 frosts were recorded at Swan Hill compared to an average of 19 and screen temperatures never fell below 0°C (Australia:

Fig. 3. Acacia melvillei stands in order of decreasing presumed age. A, dead and partly dead plants up to 5 m high at site 3. B, plants up to 4 m high, site 5. C, plants up to 3 m high, site 8. D, plants (mostly root suckers) up to 2 m high in paddock last cultivated in 1980, site 10. Scale in A, B and C is 1.4 m high.

Fig. 4. Three *Acacia melvillei* sucker shoots arising from swollen part of horizontal root following mechanical disturbance on roadside, Sturt Highway 41 km west of Balranald. Sheet of paper is 21 cm wide.

Bureau of Meteorology unpublished data). Seedling density of species other than *A. melvillei* in the plots was too low to affect the mortality rates recorded.

On 30 November 1991 only 18 plants were alive, all in cages. This number fell to six by 25 March 1992, all in a single cage from the third planting. These plants were 2–3 cm high and had 4–6 leaves, the youngest having pinnate leaves attached to phyllodes. It is surprising that any plants survived their first summer given that only 12.5 mm of rain fell in the Yarraby district between the above-average rains of September 1991 and the final inspection (J. A. McDowall personal communication). The six survivors comprise 4% of the seedlings planted in cages.

DISCUSSION

Size class analysis

The picture which emerged was of an almost total failure of *Acacia melvillei* regeneration throughout the pastoral part of the study area, with most stands seen being totally dead or with a great majority of dead trees. Similarly, of the seven arid zone *Acacia* species discussed by Auld (1990), only for *A. oswaldii* is there any chance that recruitment is sufficient to maintain current population densities.

The few exceptional sites showing some *A. melvillei* recruitment in the pastoral zone included an experimental exclosure, a home paddock, a public stock reserve and some other sites close to Balranald township with presumed intermittently low browsing pressure (the last sites were not sampled). The reasons why recruitment at some of these sites (sites 7 and 8) was not suppressed by browsing are unknown. Similarly, it

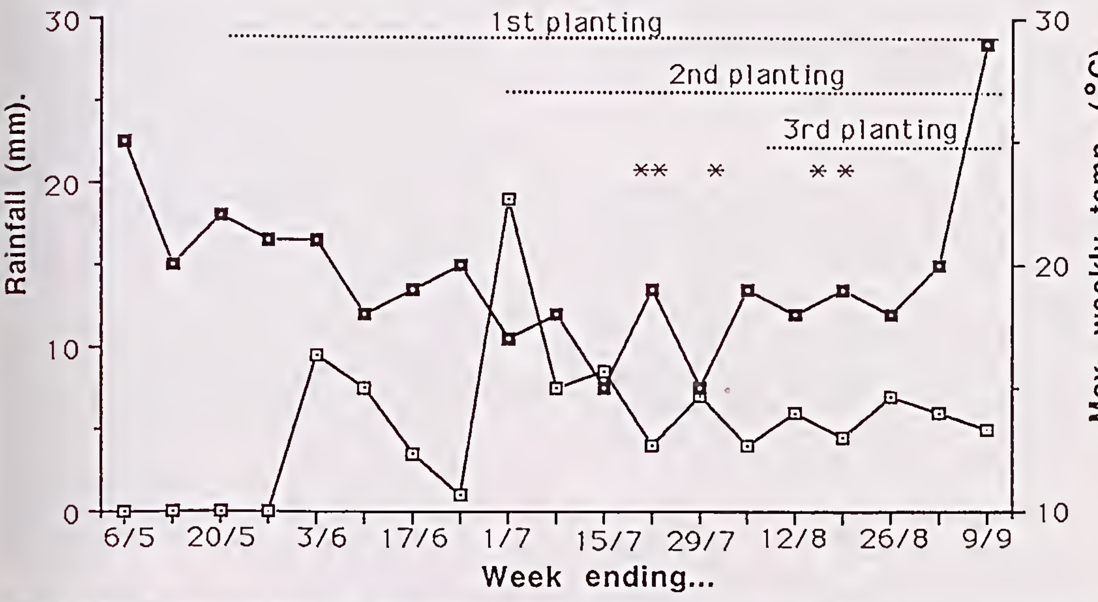

Fig. 5. Climatic data and timing of the plantings in the seedling survival trial at Flora Reserve G67. Closed squares = weekly rainfall; open squares = maximum temperature; asterisks = occurrence of frosts (from thermometer at site).

is not known why the two major recruitment episodes identified here in the pastoral zone in the last 50 years failed to occur at all the group two and three sites; relevant grazing histories are simply unavailable.

While landholders who produce profuse suckering of *A. melvillei* by cultivation regard it as a woody weed, suckers were only recorded after mechanical disturbance of roots, either in paddocks or along roadsides (Fig. 6). Thus, it seems that suckering has only been significant since introduction of European land use practices, as for *A. harpophylla* (Williams 1985). By contrast, *A. carnei* suckers independently of root disturbance, while *A. oswaldii* does not sucker at all (Auld 1990).

Fig. 6. Excavated *Acacia melvillei* specimens from sites 9 and 10 showing difference between plants originating from seedlings (left) and root suckers (right). Horizontal root is 14 cm long.

Seedling survival

The major factor limiting seedling establishment was low soil moisture, especially in spring and summer. Browsing by rabbits was also important. These findings also apply to *Acacia oswaldii* seedlings (Auld 1990) and to other species from semi-arid areas (Parsons 1968, Wellington 1989). While frost damage was not seen and mortalities did not seem to correlate with frosts, further work is needed on this given the unusually mild winter and evidence of frost deaths in other species (Parsons 1968).

Concluding discussion

It is clear from both size class analysis and the seedling survival study that, in the part of its range investigated, *Acacia melvillei* is subject to serious regeneration problems. Retaining this species in biological reserves is very likely to require strict control of rabbit populations. The same applies to pastoral areas, along with stock removal during and after the rare high rainfall events likely to be needed for successful regeneration.

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